Velocity Sense in the Lumbar Spine is Modulated by the Vestibular and Proprioceptive Systems

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INTRODUCTION

To maintain stability and normal motion of the spinal column, sensory information is necessary[1]. While studies have investigated position sense of the low back, few studies have examined velocity sense. A number of sensory systems may contribute to the perception of velocity of trunk motion. Muscle spindle organs have been shown to sense both joint position and velocity in the extremities[2]. The vestibular system could also contribute to the sense of trunk motion. In this study, the vestibular and proprioceptive contributions to the sense of low back movement were examined. It was hypothesized that altering vestibular and proprioceptive inputs would alter the sense of lateral trunk motion.

METHODS

Eight healthy subjects were recruited for the study, which was approved by the Human Subjects Committee, University of Kansas. Galvanic vestibular stimulation was applied via electrodes placed on the mastoid process behind each ear. The stimulation was set below the cutaneous threshold[3]. A vibratory stimulus device was fitted on the subject's back at L3 and adjusted to provide a 30 Hz stimulus to the underlying paraspinal muscle groups on either side of the spine independently. Subjects lay prone on a platform with their pelvis fixed, allowing only lateral trunk movement. Rotation from an optical encoder was used to provide a single audible tone for every 7º of angular displacement. Subjects were blindfolded and asked to flex laterally so that the platform generated audible tones to match a digital metronome. Target paces were 10, 15, and 20 degrees/sec. The protocol consisted of alternate training (w/ audible pace and feedback) and assessment (no audible pace or feedback) trials for each of six conditions, block randomized, for each target speed. The stimulus conditions were defined as follows: NS – no stimulation, GSL/GSR – galvanic cathode at left/right ear, VL/VR – vibration left/right sides. Each trial consisted of two consecutive right to left movements across the maximum comfortable range of lateral trunk motion.

RESULTS AND DISCUSSION

The differences between consecutive right and left movement velocities for mid-range movement were assessed. Movements were found to be faster to the right with vibration of the left paraspinal muscles than with vibration of the right paraspinal muscles. Cordo et al. found that perception of velocity of movement in the elbow could be altered for frequencies between 20 and 40 Hz with slower frequencies being perceived as slower motion[2]. The muscle vibration used here was found to be interpreted as a slower lengthening, leading to a faster movement in the non-stimulus direction to compensate for the perceived slow-down. This was particularly pronounced at the higher speed where the difference between perceived and actual speed would be greater.

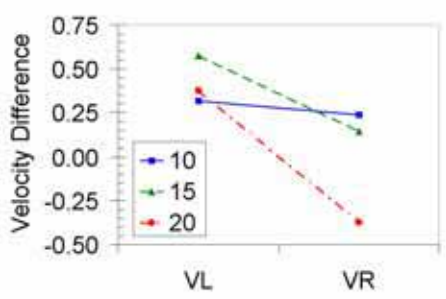

Figure 1: Right-Left velocity differences were found to be higher with vibration of the left paraspinal muscles (VL) than with vibration of the right paraspinal muscles (VR). This difference was found to increase with speed (10, 15, 20 deg/sec).

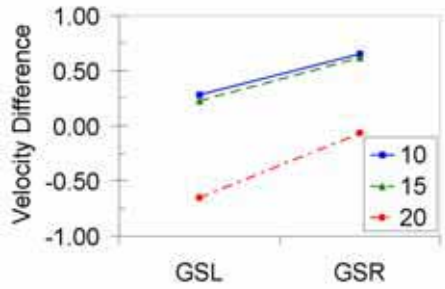

Figure 2: Right-Left velocity differences were found to be lower with galvanic vestibular stimulation with a left cathode (GSL) compared to with a right cathode (GSR). This change was found to be independent of speed (10, 15, 20 deg/sec).

With galvanic vestibular stimulation (GVS), movement towards the cathode was found to be faster for both left and right stimuli at all speeds of movement. GVS has previously been shown to induce a perceived motion towards the cathode in studies of dynamic sway[3]. This suggests that the vestibular system also plays a role in perception of velocity.

CONCLUSION

Both the proprioceptive and vestibular systems have been shown to play a role in the sense of lateral, low-back velocity. Vibration-induced changes in kinesthesia have been found to be a function of the speed of motion. Future research should examine the frequency dependence of these changes.

REFERENCES

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